

Microbiological Consequences of Skin Removal Prior to Evisceration of Broiler Carcasses

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ABSTRACT The objective of this project was to determine if removal of skin prior to evisceration lowers the number of bacteria that can be recovered by whole carcass rinse or sponge sampling. Four experiments were conducted, two with each type of sampling (rinse or sponge). New York dressed carcasses obtained from a commercial broiler processing plant were aseptically skinned or left with skin intact. The carcasses were then aseptically eviscerated by hand. Carcasses were rinsed in 100 mL sterile water or sampled by moist sponge. When sampled by rinse, significantly fewer *Campylobacter* and total aerobic bacteria were recovered from carcasses that had been skinned prior to evisceration. When sampled by sponge, significantly fewer *Campylobacter*, *Escherichia coli*, coliform and total aerobic bacteria were recovered from the outer surface of carcasses without skin. No differences were

noted for bacterial counts recovered from internal surfaces by sponge sampling. Similar trends were observed when carcasses were subjected to an inside and outside washing step after evisceration. Removal of skin and washing the carcass led to significantly less *Campylobacter* being recovered by whole carcass rinse compared to carcasses that were washed with the skin on. When sampled by sponge, incidence of *Campylobacter* and level of total aerobic bacterial counts were lower on the outer surface of skinned and washed carcasses than on washed carcasses with intact skin. Like the unwashed carcasses, no differences were noted for bacterial counts recovered from internal surfaces by sponge sampling. Although not commercially practical, it is possible to lower the level of *Campylobacter* on the outside of broiler carcasses by removal of the skin prior to evisceration.

(Key words: broiler, *Campylobacter*, *Escherichia coli*, processing, skin)

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INTRODUCTION

Campylobacter is an important human pathogen that is commonly associated with poultry and poultry products (Kotula and Pandya, 1995; Ridsdale et al., 1998; Saleha et al., 1998; Berrang and Dickens, 2000). Six hundred twenty-seven cases of campylobacteriosis were reported in Georgia between September 1999 and September 2000 (Georgia Department of Human Resources, 2000). Most experts agree that many more cases go unreported. Indeed, the Centers for Disease Control estimates that there are more than 2 million cases of campylobacteriosis each year in the US, and that 80% of these are due to foodborne transmission (Mead et al., 1999).

Campylobacter is often present on the skin of broilers, with high numbers found in positive flocks. Oosterom et al. (1983) reported from log₁₀ 2.4 to 6.6 cfu/g of pericloacal

skin before scald and from log₁₀ 1.1 to 4.0 after defeathering. Izat et al. (1988) recovered similar levels of *Campylobacter* from broiler skin by breast and thigh surface swabs. Kotula and Pandya (1995) report levels of log₁₀ 6.9 cfu/g of breast skin prior to scald. Berrang et al. (2001) reported a mean of log₁₀ 3.8 cfu *Campylobacter*/g of broiler breast skin prior to scald.

Campylobacter numbers recovered by whole carcass rinse or by skin surface swab tend to decrease after the carcass is scalded but increase following defeathering (Oosterom et al., 1983; Izat et al., 1988; Berrang and Dickens, 2000). *Campylobacter* is also present in high numbers in the alimentary tract (Oosterom et al., 1983; Byrd et al., 1998; Berrang et al., 2000). Barring intestinal rupture, however, much of the *Campylobacter* that is carried into the plant after defeathering is on the skin. On a New York dressed carcass, the meat underlying unbroken skin is essentially sterile (Avens and Miller, 1973; Berrang et al., 2001). However, the skin can carry a substantial number of bacteria including *Campylobacter*.

Stern et al. (1995) found that removal of the skin with feathers attached is extremely difficult to do without contamination of the underlying tissue. This observation has

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TABLE 1. The effect of pre-evisceration skin removal on mean bacterial counts (\log_{10} cfu/sample) recovered by whole broiler carcass rinse (Experiment 1)

Skin ¹	<i>Campylobacter</i>	<i>Escherichia coli</i>	Coliforms	Total aerobes
Skin on	5.4	4.4	4.9	6.7
Skin off	4.7*	3.9	4.4	5.8*

¹ Three replications, five carcasses per replication (n = 15).

*Indicates a significant difference due to removal of skin, as measured by general linear model procedure ($P \leq 0.05$).

been confirmed in our laboratory (Berrang, unpublished data). However, removal of the skin after defeathering may also remove the contamination associated with feathers. If skin could be removed early in the process, the *Campylobacter* associated with it could be avoided. Although this removal presents significant technical hurdles in terms of product processing, meat quality and maintenance of yield, it may be possible to reduce bacterial counts on ready-to-cook poultry. The objective of these studies was to determine if aseptic removal of skin prior to evisceration has an affect on the numbers of bacteria including *Campylobacter* on broiler carcasses. These experiments were conducted in a pilot plant under experimental conditions and were not meant to suggest the possibility of immediate application in commercial processing.

MATERIALS AND METHODS

Experimental Design

Four sets of experiments were conducted to test the effect of skin removal prior to evisceration on bacterial numbers. In each experiment, defeathered carcasses were collected from the line in a commercial broiler processing plant after the head puller and before the hock cutter. On each of three replicate sample days, 10 carcasses were placed in sterile bags, sealed, covered with ice, and transported to the laboratory. Five birds were aseptically skinned, and five were left with the skin intact. The treatments were alternated to prevent any affect of continued cold storage on the microbial populations. In Experiment 1, carcasses were examined by whole carcass rinse after evisceration by hand. In Experiment 2, the carcasses were examined by sponge wipe over the outside surface with a separate sponge used for the inside surface. Experiments 3 and 4 were the same as Experiments 1 and 2 with the addition of an inside and outside wash after evisceration but before sampling.

Skinning

With the carcass hanging by the neck in a J-hook, the wings were aseptically removed at the elbow, and the feet were removed at the hock. New latex gloves were worn during the skinning procedure, and every effort was made to ensure the outer surface of the skin did not contact the exposed underlying tissue. With a sterile scalpel, a circular incision was made around the neck

well above the crop. Two separate incisions were then extended downward along the dorsal midline to a point above the tail and the ventral midline to the abdomen. Connective tissue and fat beneath the skin were gently dissected to loosen the skin as the skin was pulled downward and away from the underlying tissue on both sides of the carcass. To avoid contamination from accidentally cutting the digestive tract, blunt dissection with the gloved hand was used to separate the skin from the crop. The dissection was continued until there was enough skin to grasp firmly. Each flap of skin was then held in both hands and pulled downward. In this fashion, the skin could nearly be pulled off the carcass in one piece, turning inside out. The skin was removed from the carcass by pulling over the leg bones and slicing at the tail with a sterile scalpel. The tail and vent were left to be removed together during evisceration.

Evisceration

Carcasses were hung by the neck in a J-hook; if the skin had not been removed, it was cut with a sterile scalpel on the ventral midline of the neck to expose the crop and esophagus. The rest of the evisceration procedure was identical for carcasses with and without skin. A plastic cable tie was used to tie the esophagus between the crop and the proventriculus. A clamp was placed on the esophagus just above the cable tie, and the esophagus was cut between the clamp and cable tie to prevent leakage from the crop. The crop was removed toward the head. A cut was made through the tail with a sanitized knife, and then the abdomen was opened by carefully cutting with sanitized scissors. The carcass was eviscerated by inserting a hand, grasping the tied esophagus and proventriculus, and pulling the viscera down. Each proventriculus was examined for signs of leakage during evisceration. When all viscera were hanging out of the opening in the abdomen, the vent and tail were cut off with scissors, allowing the alimentary tract to fall away from the carcass without contacting sample surfaces.

Washing

In Experiments 3 and 4, carcasses were subjected to a simulated inside and outside wash in a cabinet. Carcasses were placed with the abdominal opening down on a wire cone suspended on a sealed bearing to allow it to freely spin. The cabinet was outfitted with a series of spray

TABLE 2. The effect of pre-evisceration skin removal on mean bacterial counts (\log_{10} cfu/positive sample) recovered by external and internal broiler carcass sponge sampling (Experiment 2)

Site ¹	Skin	<i>Campylobacter</i> ²	<i>Escherichia coli</i> ²	Coliforms ²	Total aerobes
External	Skin on	4.5 (15)	3.7 (15)	4.3 (15)	5.6
	Skin off	2.8* (5)†	2.3* (10)†	2.3* (12)	3.3*
Internal	Skin on	3.5 (9)	3.4 (14)	3.5 (15)	4.6
	Skin off	3.0 (6)	3.4 (14)	3.7 (14)	4.8

¹Three replications, five carcasses per replication (n = 15).

²Value is mean of positive samples, number in parenthesis is the incidence of positive samples detected out of 15 tested.

*Indicates a difference in level due to removal of skin, as measured by general linear model procedure ($P \leq 0.05$).

†Indicates a difference in incidence due to removal of skin, as measured by chi-squared test ($P \leq 0.05$).

nozzles.² The outer surface of the carcass was subjected to 12 spray nozzles in four banks at 90-degree placements to cover the front, back, and each side of the carcass. Nozzles were angled using adjustable joints² such that the spray pattern caused the carcass to spin clockwise and allowed an even spray on all surfaces. Each bank of nozzles included one 1/8P 3504 flat spray, one 1/4 P 5010 flat spray, and one 1/4 VV 40015 v-jet. The inner surface was subjected to water from a 3/8GG 3009 full-jet nozzle. Each carcass was sprayed with tap water for 1 min at 25 psi, which produced a flow rate of 5 gal/min. An electric timer connected to a solenoid valve was used to adjust the spray time to 1 min.

Microbiological Methods

Carcasses were sampled by whole carcass rinse or an overall sponge sample method. Whole carcass rinsing was conducted by placing each carcass in a sterile plastic bag, adding 100 mL sterile water, and vigorously shaking by hand for 60 s. Sponge sampling was done with Speci-Sponge³ samplers. Each sponge, in a self-contained sample bag, was premoistened with 10 mL sterile PBS and rubbed over the entire outer or inner surface of the carcass. Fifty milliliters of PBS was added to each sponge sample bag, and the sample was subjected to 30 s blending in a stomacher.⁴

Serial dilutions from both sample types were made in PBS, and *Campylobacter* was enumerated by plating in duplicate onto the surface of Campy-cefex agar (Stern et al., 1992) plates. One-tenth milliliter was spread on the surface of each plate with a sterile plastic inoculating loop, and plates were incubated at 42 C for 24 to 48 h in a microaerophilic environment (5% O₂, 10% CO₂, and balance N₂). Colony-forming units characteristic of *Campylobacter* were counted. Each colony type counted

as *Campylobacter* from each sample was confirmed as a member of the genus by examination of cellular morphology and motility on a wet mount under phase contrast microscopy. Each colony type was further characterized as a member of the species *jejuni*, *coli*, or *lari* by a positive reaction on a latex agglutination test kit.⁵ Total aerobic bacterial populations were enumerated on plate count agar.⁶ One-tenth milliliter from a serial dilution was plated in duplicate on the surface of the agar, spread, and incubated at 37 C for 18 to 24 h prior to counting the resulting colony-forming units. Coliform and *Escherichia coli* counts were made by plating 1 mL from a serial dilution onto duplicate E. coli PetrifilmTM plates.⁷ PetrifilmTM plates were incubated at 37 C for 18 to 24 h, and colony types characteristic of coliforms and E. coli were counted.

Statistical Analysis

All bacterial counts were transformed to \log_{10} colony-forming units per sample. Numbers recovered from samples with and without skin, within each experiment, were compared by general linear model using a randomized complete block design with replicate sample day as block. Incidence values in the sponge sample experiments were compared by chi-squared test. All statistical analyses were conducted using Statistica software (Release 5, 1997 Edition).⁸

RESULTS AND DISCUSSION

Removal of skin prior to evisceration lowered the number of *Campylobacter* recovered from whole carcass rinse samples compared to paired carcasses with the skin left on (Table 1). The total aerobic bacterial counts were also lower. However, *E. coli* and coliform counts were not different, depending on the presence or absence of skin. Although significant ($P < 0.05$), the difference in *Campylobacter* counts for carcasses with and without skin was somewhat less than 1 \log_{10} . A whole carcass rinse contacts the inside as well as the outer surfaces of an eviscerated broiler carcass. It was not readily apparent how many *Campylobacter* were being recovered from internal sur-

²Spraying Systems Co., St Petersburg, FL 33738.

³Nasco Whirl-Pak, Fort Atkinson, WI 53538.

⁴Seward Limited, London, N2 0GN, UK.

⁵Integrated Diagnostics, Baltimore, MD 21227.

⁶Becton Dickinson and Co. Sparks, MD 21152.

⁷3M Microbiology Products, St Paul, MN 55144.

⁸Statsoft, Tulsa, OK 74104.

TABLE 3. The effect of pre-evisceration skin removal and post-evisceration inside and outside washing on mean bacterial counts (\log_{10} cfu/sample) recovered by whole broiler carcass rinse (Experiment 3)

Skin ¹	<i>Campylobacter</i>	<i>Escherichia coli</i>	Coliforms	Total aerobes
Skin on	5.4	3.3	3.7	5.9
Skin off	3.8*	3.8	4.2	5.6

¹Three replications, five carcasses per replication (n = 15).

*Indicates a difference due to removal of skin, as measured by general linear model procedure ($P \leq 0.05$).

faces as opposed to the outer surface from which the skin was removed.

Sponge sampling was used in Experiments 2 and 4 to segregate the populations associated with inner and outer surfaces of carcasses. When sampled by sponge, the *Campylobacter* counts recovered on the outer surface of carcasses skinned before evisceration were 1.7 log less than those with skin on (Table 2). *Campylobacter* was detected on significantly more ($P < 0.05$) carcasses with the skin on (15) than with the skin off (5). Interestingly, no significant difference in *Campylobacter* recovery was noted from the inside of carcasses with and without skin. This trend was observed for all populations measured. On the outer surfaces, numbers of *E. coli*, coliforms, and total aerobic bacteria were lower with the skin removed. No difference was noted in these populations when the inside of the carcass was sampled. Overall, the numbers of bacteria recovered from the outer surface decreased due to the removal of skin, and the numbers of coliforms and total bacteria recovered from the internal surface did not differ with removal of the skin.

Some bacteria can be removed from broiler carcasses by spray washing with water. It is possible that additionally removing skin and spray-washing is more effective than spray washing alone. To test the addition of a wash step to further reduce counts associated with broiler carcass rinse samples, a post-evisceration inside and outside wash step was added. Removing skin before evisceration and washing after evisceration resulted in significantly lower *Campylobacter* recovery compared to carcasses that were only washed (Table 3). However, numbers of *E. coli*, coliform, or total aerobic bacteria recovered were not

different depending on the presence of skin on washed carcasses.

Another set of experiments with sponge sampling was conducted to measure bacterial populations associated with the inside and outside of washed carcasses. The outer surface of washed carcasses that had been skinned prior to evisceration had a lower incidence of detectable *Campylobacter* and fewer total aerobic bacteria per sample than those with the skin on (Table 4). However, like sponge samples from unwashed carcasses, these differences did not appear on the inside surfaces. As in Experiment 2, the number of bacteria recovered from the outer surface tended to decrease due to the removal of skin. Those recovered from the internal surface did not differ with the removal of skin. This finding suggests an interaction between the presence of skin and the site sampled (inside or outside of the carcass).

It appears that the level of *Campylobacter* recovered from whole broiler carcass rinse samples can be lowered by removal of skin, and associated contamination, early in processing. When considering only the outer surfaces, the levels of *Campylobacter*, *E. coli*, coliforms, and total aerobic bacteria all decreased.

Hundreds of *Campylobacter* cells can be recovered from the internal surfaces of eviscerated broilers, even when there is no evidence of contamination with alimentary tract contents. Large numbers of other bacteria have also been recovered by rinsing the internal surfaces of broiler carcasses. Blankenship et al. (1975) described an internal rinse procedure that allowed recovery of \log_{10} 5.0 cfu total aerobic bacteria per carcass. By using another internal rinse procedure, Lillard (1991) found that numbers

TABLE 4. The effect of pre-evisceration skin removal and post-evisceration inside and outside washing on mean bacterial counts (\log_{10} cfu/positive sample) recovered by broiler carcass sponge sampling (Experiment 4)

Site ¹	Skin	<i>Campylobacter</i> ²	<i>Escherichia coli</i> ²	Coliforms ²	Total aerobes
External	Skin on	3.1 (14)	2.2 (14)	2.5 (15)	4.3
	Skin off	2.7 (6)†	1.8 (9)†	2.1 (12)	2.8*
Internal	Skin on	3.1 (10)	2.7 (10)	3.1 (14)	4.4
	Skin off	3.0 (10)	3.2 (13)	3.7 (14)	4.9

¹Three replications, five carcasses per replication (n = 15).

²Value is mean of positive samples, number in parenthesis is the incidence of positive samples detected out of 15 tested.

*Indicates a difference in level due to removal of skin as measured by general linear model procedure ($P \leq 0.05$).

†Indicates a difference in incidence due to removal of skin, as measured by chi-squared test ($P \leq 0.05$).

of bacteria recovered from the internal surfaces were no different than those recovered from the outer surface. It is possible that internal contamination of broiler carcasses is partly a result of bacteria being present in the air sacs that are torn during evisceration (Thomson and Kotula, 1959). Skinning as described herein is slow and tedious. Commercial skinning machines being used prior to evisceration should be tested to see if the same promising results are noted when running at a speed more amenable to modern line speeds. It may be possible to lower the numbers of *Campylobacter* found on broiler carcasses by altering processing to include skin removal prior to evisceration. However, such a change would require overcoming significant problems in terms of maintenance of product quality and yield throughout processing and may be impractical at this time.

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